Remedial Performance of Organic Mulch Biowalls at Two Geochemically Distinct Sites

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Introduction:

Given the past intensive use of chlorinated solvents in the industrial setting and the resultant impact of these solvents in ground water resources, there is strong pressure to develop technologies that can effectively and cost-effectively treat these aquifer contaminants. Often times a treatment model exists in nature. The challenge is to understand these natural models sufficiently to apply and enhance these natural contaminant treatment processes in the form of engineered remediation systems. Reductive dechlorination is a naturally-occurring process that has been both observed in numerous natural subsurface environments and applied as an enhanced remediation method. The *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (US EPA, 1998) outlines methods to quantify chlorinated solvent destruction in situ. In addition, this protocol describes the biogeochemical conditions under which the destruction of chlorinated solvents occurs. One of the unique environments under which chlorinated solvents are subject to destruction is termed Type 2 conditions. Type 2 conditions are primarily established by the presence of a naturally-occurring source of organic carbon. The presence of this naturally-occurring organic material could be the result of numerous geologic processes where plant materials or organic-rich muds are buried in the environment. This naturally-occurring organic carbon can act as an energy source (i.e. electron donor) for subsurface microbes. This biodegradation of this organic carbon results in the establishment of reducing conditions and creates a demand for electron acceptors. Chlorinated solvents (e.g. Tetrachloroethene, trichloroethene, etc) are highly oxidized compounds and can be used by microbes as electron acceptors under Type 2 anaerobic conditions. The organic mulch biowalls described in this paper represent deliberate attempts to mimic Type 2 degradation of chlorinated solvents at two geochemically distinct field sites. Since naturally buried plant materials have resulted in the establishment of Type 2 chlorinated solvent destruction conditions, it follows that the engineered placement of organic plant materials has the potential to promote enhanced chlorinated solvent treatment via reductive dechlorination. This concept has been deployed through the construction of two in situ permeable reactive treatment biowalls at Offutt Air Force Base (AFB), Nebraska and one at Altus AFB, Oklahoma.

Materials and Methods:

Hydrogeological and biogeochemical sample collection and analysis procedures were conducted in accordance with the Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water (US EPA, 1998).

The three organic mulch biowalls covered in this paper were installed using a continuous trencher rig which allowed for the near simultaneous removal of subsurface soils and placement of organic mulch mixtures. Aquifer dewatering was not required.

The first biowall (100 ft. (L) x 1 ft (W) x 23 ft (D)) was installed at Offutt AFB, NE in January 1999 using composted shredded tree mulch mixed with coarse sand (50:50 ratio). Sand was added for the maintenance of increased hydraulic conductivity, density, and for long-term trench stability. Organic mulch was generated and supplied by the Offutt AFB Civil Engineering Squadron. A surplus of shredded organic plant material was generated as part of a severe winter storm cleanup effort. This winter storm (fall 1998) caused the icing and sudden limb drop of on-base native and landscape trees. The tree material that was shredded in a tub grinder contained both lighter twig and leaf materials as well as heavier limb materials. This material was stockpiled and was in a state of active thermogenic composting immediately prior to the January 1999 biowall construction effort.

A 455 feet long by 24 feet deep by 1.5 feet wide organic mulch biowall was installed at Altus AFB, Oklahoma, Solid Waste Management Unit 7 (SWMU 7) in June 2002. Approximately 300cubic yards (yd^{3}) tree mulch, 60 yd^3 cotton gin compost, and 265 yd^3 sand were mixed on-site and emplaced using a continuous trenching rig. The tree mulch and cotton gin compost were provided at no-cost. A supplemental ten (10) ground water monitoring well, four (4) soil gas monitoring network was installed and sampled in July 2002 (4 weeks after installation). Subsequent sampling and analysis was conducted in September 2002 (8 weeks after installation).

Results and Discussion:

Data detailing the resultant changes in site geochemical and chlorinated solvent degradation profiles will be presented. Comparisons of geochemical profiles before and after organic mulch emplacement indicate a progression toward more reducing conditions. Significant shifts in cis-1,2dichloroethene (cis-DCE) to TCE ratios were exhibited in all biowalls. Vinyl chloride and ethane were detected in and immediately downgradient of all biowalls. Vinyl chloride did not accumulate above concentrations of concern (e.g. 10 times maximum concentration limits (MCLs)) in any of the biowalls.

Ground water samples collected directly in and five (5) feet downgradient of the Altus AFB biowall exhibited iron sulfide formation. Iron sulfide compounds have been shown to promote the abiotic reductive dechlorination of chlorinated ethenes (Butler, 1999). The AFCEE is further investigating this observation to quantify actual abiotic contaminant destruction using its *Technical Protocol For Natural Attenuation Assessments Using Solid And Aqueous Electron Acceptors* (AFCEE/ERT, 2000).

This work demonstrates that in situ permeable biowalls containing inexpensive organic material derived from shredded plant matter can enhance in situ reductive dechlorination at two geochemically distinct sites. In addition, this work provides practical lessons-learned and guidelines for the proper application, design, and construction of these treatment systems.

References:

Butler, E. C., and K. F. Hayes, 1999. *Kinetics Of The Transformation Of Trichloroethylene And Tetrachloroethylene By Iron Sulfide*, Environmental Science Technology, 33:2021-2027.

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